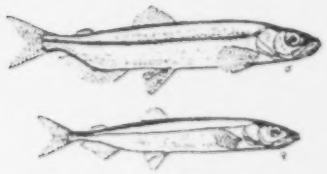


STOCK STATUS REPORT
CAPELIN IN SUBAREA 2 + DIV. 3KL

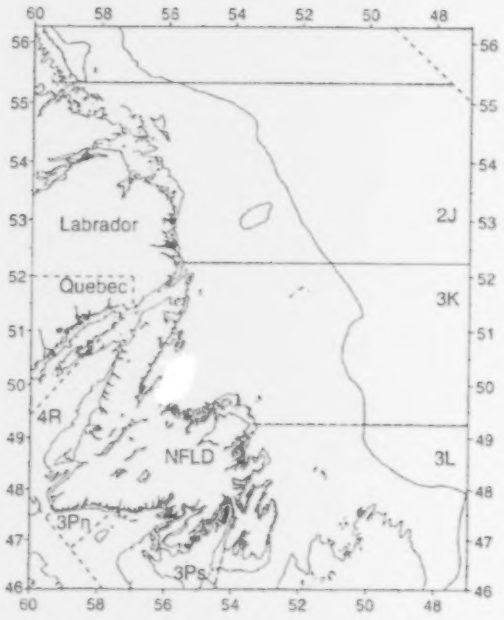
Background

Capelin (Mallotus villosus) is a small pelagic schooling species with major populations occurring in the Northwest Atlantic, in waters around Iceland, in the Barents Sea and in the northern Pacific. For several years, capelin in SA2 + Div. 3K and Div. 3L were treated as two stocks but, as a result of accumulated evidence, scientists recommended in 1992 that capelin in these areas be considered one stock complex.

Adult fish range in size from about 12 to 23 cm with males being larger than females. The spawning populations are composed of mainly three and four year old fish. The short life span and variable recruitment offer the potential for frequent and dramatic changes in mature biomass.

Juvenile capelin of the SA2 + Div. 3KL stock can be found both in major bays and in offshore waters although the northern Grand Bank and Northeast Newfoundland Shelf are thought to be major nursery areas. At maturity, schools of adults migrate inshore to spawn on Newfoundland beaches during June and July. After the eggs have hatched, the larvae exit the beach gravel and most are carried out of the bays rapidly by surface currents.

Capelin are eaten by many predators including seals, whales, cod, Greenland halibut, salmon and seabirds. They are considered to be a key element in the food chain. Because of this prominent position in the ecosystem a conservative approach to their management has been adopted. In the late 1970's, scientists recommended that no more than 10% of the projected mature biomass be removed annually in a commercial fishery.



The Fishery

Historically, a small domestic fishery (annual harvest estimated at about 25,000 t) for capelin on the Newfoundland spawning beaches existed to provide food, bait and fertilizer. A directed foreign offshore fishery began in the early 1970's and was closed in Div. 3L and in Div. 2J3K beginning in 1979 and 1992, respectively. During the late 1970's, an inshore fishery for roe capelin began. Throughout the 1980's, the inshore fishery usually started by mid-June in the south and finished about mid-July in the north.

April 1999

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Gear types in the inshore fishery are traps, purse seines and, to a lesser extent, beach seines. The primary market is for frozen roe-bearing female capelin in Japan. This market is limited and the demand for quality is high. Failure to meet quality standards results in discarding. Most discarding is believed to occur after the fish are landed and since the TAC is applied to the landings, these discards are accounted for in the application of the TAC.

In 1994 and 1995, the average size of female capelin in most areas was too small to meet the management plan size criterion of 50 count/kg (sea run). As a result, the fishery either did not open or opened for only a short time and catches were low.

Beginning in 1996, the management plan has not included a size criterion and a fishery has occurred. During 1997 and 1998, fish were monitored by some sectors of the industry with the aim of opening the fishery when fish met market requirements. A summary of catches and TAC's (tons x 10^{-3}) since 1992 is given below.

	1992	1993	1994	1995	1996	1997	1998
SA2 + Div. 3K							
TAC	17	11.4	11.5	11.5	9.7	11.4	11.4
Nominal catch	18	13[a]	<.1[a]	<.1[a]	8.9[a]	9.2	10.4[a]
Div. 3L							
TAC	19.3	21	21	22	18.3	21.7	21.7
Nominal catch	3	23[a]	1[a]	1[a]	16.8	3.6[a]	20.3[a]
SA2 + Div. 3KL							
Total nominal catch	21	36	1	1	25.7	12.8	30.7

a provisional

Multispecies Considerations

Capelin is considered a key forage species. Estimates of consumption of capelin by predators are available, although many have not been updated for several years. Consumption estimates can vary depending on the assumptions underlying the calculations, however, they serve to illustrate sustenance provided to predators. Puffins were estimated to consume about 12,000 tons during the breeding season alone. Capelin consumption by seabirds was estimated at about 250,000 tons annually in the mid 1980's. Minke and fin whales were estimated to have consumed about 400,000 tons prior to their decline several decades ago. There are no new consumption estimates for whales. The most recent estimates for harp seals indicate about 700,000 tons of capelin were consumed in 1998 compared to about 350,000 tons in the early 1980's. Previous estimates for cod consumption indicated that during the early 1980's, cod in Div. 2J3KL were consuming 0.7 to 2.25 million tons of capelin annually. During the same time period, a minimum of 200,000 tons of capelin was estimated to have been consumed by Greenland halibut. Because the consumption estimates are calculated using predator biomass, they will vary with the marked changes in biomass of the various predators over time. Groundfish predators of capelin, such as cod, Greenland halibut and American plaice have declined in abundance from the early 1980's to the present. Harp seals have increased in abundance during that time. Based on the consumption estimates available, the increase in capelin consumption by harp seals is not as great as the decrease in consumption by groundfish predators.

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There is considerable evidence that seabird ecology has changed in recent years. Differential breeding success of two species of seabirds in the Witless Bay area during the 1990's appeared to be related to the vertical availability of capelin. Kittiwakes, which are shallow divers, experienced relatively low breeding success during the early 1990's. Breeding success improved during 1996 and 1997 and approached historical levels.

The timing of kittiwake breeding was later in the 1990's, and like the delay in capelin spawning, appeared to be related to environmental factors. Puffins are a deeper-diving species and in contrast to kittiwakes, they have experienced good breeding success during the 1990's. Data on breeding success for these species were not available for 1998, however, it was noted that the weight of capelin in the diet of puffin chicks was lower in 1998, compared to 1997.

On Funk Island, gannet chick diets have shown a food change over two decades (1977-97) with capelin occurring in higher proportions in the 1990's. This shift to capelin is believed to be a result of greater availability of capelin during the chick feeding period, consistent with the later capelin spawning during the 1990's, and lower availability of warm-water species such as mackerel and squid. Data for 1998 were not available.

At the Gannet Islands, off the coast of Labrador, the weight of capelin in the diets of puffin chicks increased in 1997 and 1998, compared to 1996.

Biology and Resource Status

During the early 1990's, several biological changes, coincident with below normal water temperatures, have been documented. During offshore fall surveys in the 1980's, capelin were widely distributed from Div. 2J to Div. 3L, with a cline of larger to smaller capelin from north to south. In the early and mid-1990's, few capelin have been observed in Div. 2J and northern Div. 3K while most have been detected in southeastern Div. 3K and northern Div. 3L. The trends in size have been similar to the 1980's with larger capelin occurring in the northern part of the new distribution range and smaller capelin in the south. Also during the 1990's, capelin abundance measured by acoustic surveys was low.

Capelin distribution appears to be changing to more closely resemble the distribution observed in the 1980's. This was apparent in the distribution of capelin bycatch in the fall 1998 groundfish survey, continuing a trend that was first observed in fall 1997. In these years, capelin appeared more extensively in western Div. 3K and southern Div. 2J. Capelin bycatch in spring groundfish surveys in Div. 3L showed a broad distribution in 1996-98. This is similar to distributions observed in the mid- to late 1980's.

Surveys for young fish also detected 0-group capelin off the southern Labrador coast in 1998, the first appearance in the series (1994-98). In the same survey, ripe adult capelin and recently hatched larvae were detected in the Southeast Shoal area (Div. 3LNO); such occurrences had not been recorded in earlier surveys. These changes in

capelin distribution are reminiscent of distributions observed during the 1980's, and are considered the first indicators that capelin may be exhibiting distributions and behaviour considered more typical than previously observed in the early 1990's. These changes are also coincident with a general warming of seawater in the Newfoundland region.

During the late 1980's and through the 1990's, capelin bycatches increased one hundred fold in groundfish surveys on the eastern Scotian Shelf (Div. 4VW). Capelin occur sporadically in this area and as a result, it is not known whether the increase was a result of immigration or enhanced reproductive success. Capelin also appeared on the Flemish Cap (Div. 3M) during the 1990's as bycatch in groundfish surveys and the shrimp fishery. Historically, capelin were rare here and this appearance was most likely due to migration. Increases in abundance in both areas, both historically and recently, have coincided with cold water. There are no new data for Flemish Cap but preliminary results from the eastern Scotian Shelf indicate that March 1999 bycatch levels remain high.

The average size of capelin declined during the 1990's and has remained small. The timing of inshore spawning was delayed during the 1990's and this trend has also continued. The later spawning has been correlated with colder water and smaller fish size. Although there is a general warming trend in sea temperature, fish size remained small in 1998 and it may be that spawning will continue to be later unless sizes return to normal.

Other observations of unusual characteristics of capelin biology during the 1990's, not documented in the scientific literature, include: an increase in the relative proportion of spawning at night; changes in physical structure of the otoliths causing problems in age determinations; an increased incidence of females with ovaries full of unspawned eggs in the fall; a consistent and relatively high proportion of spent females in the fall since 1992.

In general, it appears that some characteristics of capelin such as offshore distributions are changing to more closely resemble patterns observed in the 1980's. Although the observations are at this stage qualitative, the dramatic shifts in the early 1990's appeared to be linked with below normal seawater temperatures whereas the reversal of this pattern now seems to be occurring with a warming trend.

Evaluation of Resource Status

In the past evaluations of resource status, seven partially overlapping series of indicators were combined in a mathematical model to provide relative estimates of yearclass strength. The indicators and their years of existence are:

1) aerial survey index 1982-98
2) purse seine catch rate index 1981-96
3) trap catch rate index 1981-93
4) groundfish 3L fall bycatch 1985-94
5) groundfish 2J3K fall bycatch 1985-94
6) Russian 2J3K fall commercial catch rate index 1972-91
7) egg deposition index 1990-98

The 1998 aerial survey index was lower than 1997 and below the 1990-98 average. The egg deposition rate was the highest in the

series (1990-98). Catch rate data from purse seines and traps in 1997 and 1998 are not considered comparable to catch rate from the 1980's because of low effort levels, in part due to quality monitoring. As a result, catch rate data for these years were not used in the model. A change in the gear in the fall groundfish survey in Div. 2J3KL in 1995 has effectively produced a new series which will be examined in more detail in the future for possible inclusion in the model.

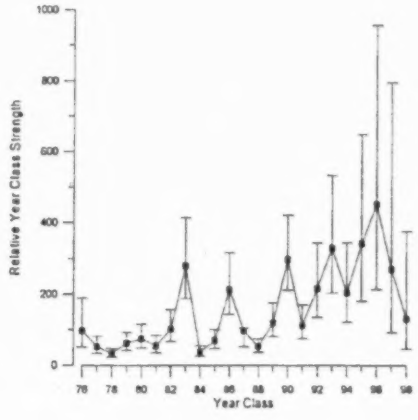
A second mathematical model was also incorporated into past assessments. This model produced a recruitment index using results from surveys for larvae and one-year-olds. The indicators used in this model and their years of availability are:

1) 0-group index 1994-98
2) sediment larval index 1990-98
3) emergent larval index 1990-98
4) Conception Bay sediment larval abundance 1987-93
5) oceanic age 1 index 1994-98

The trends in relative yearclass strength between the two indices were similar and as a result, the 12 indicators were combined into one model in this assessment. Combining the data provides more information for the evaluation of yearclasses that are expected to contribute to the spawning stock in 1999. It also contains the information on the youngest yearclasses (1997 and 1998) which was previously contained in the recruitment model alone.

The method of combining the indices in the model was also refined in this assessment. In previous assessments, individual indicators were given equal weight in the process of combining them. In the current assessments, importance of inclusion of each indicator was determined by the amount of uncertainty in its contribution to the overall index. Indicators with high uncertainty contributed less to the final index.

According to these results, the 1990's might be characterized as a period of relatively strong yearclasses compared to the 1980's. However, the standard errors are so large in recent years that the relative abundances of many of the yearclasses are statistically indistinguishable.



In previous years, an additional mathematical model (which included an assumption that recruitment does not change) provided trends in mature biomass. This model was not updated. It is clear that one of the major assumptions, that is, constant yearclass strength, is violated. Furthermore, standard errors were so large that trends in mature biomass over the time series (1980-present) could not be identified.

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Sources of Uncertainty

Many sources of uncertainty cited in the previous stock status reports remain. These included the large-scale changes in distribution, the unreconciled divergence between low offshore acoustic estimates and inshore indices in the 1990's, difficulties in ageing capelin in the 1990's compared to earlier years and the large statistical uncertainties from the mathematical model. The mathematical models used assume that a number of things are constant over time; for example, maturity schedules and survival rates. The effects of violations of these assumptions have not been examined.

While the use of the method to determine the relative contribution of indicators in the formulation of the model is considered an improvement, there remains particular concerns about the indices themselves and whether they are now providing reliable indicators of stock status. These concerns were identified in last year's stock status report but are repeated here because they are critical to the assessment.

During the 1980's, catch rates and other indices showed similar annual patterns. However, catch rates may now be poor indicators of stock status. Fishing effort has declined in recent years, due in part to monitoring for quality and fishing only when the fish meet market requirements. This results in catch rates which probably cannot be compared to the 1980's and may not reflect stock status. Both the aerial survey and egg deposition studies which provide fishery-independent indices, have been reduced in geographical coverage and/or intensity. The aerial survey now covers only the transects in the inner parts of Trinity and Conception Bays. The only beach study area is Bellevue Beach compared to six study beaches (three in each of Div. 3L and 3K) in the original study. There are two major concerns with the 1997 and 1998 aerial and beach surveys: 1) they are so limited in geographical coverage compared to the overall stock area that the results may not reflect status of the whole stock, and 2) there were indications from the 1997 opinion survey that abundance may be changing at different rates within the stock area, for example, within the bays versus near headlands. If this is the case, the limited geographical coverage by the aerial and beach survey may not detect these changes. While the offshore surveys for early life stages (primarily 0- and 1-group) are continuing, acoustic surveys for older juveniles and adults have been discontinued. While it appears that the acoustic survey may be re-instated, there is likely to be a period of a few years before estimates of abundance will be available. The concern that scientific investigations have been reduced to such an extent that it may not be possible to assess the status of capelin stocks, expressed in last year's stock status report has not diminished.

There is also concern over the divergence between the assessment using the mathematical model and the opinions of fixed gear fishermen, particularly the contradiction in comparisons between the 1990's and earlier periods. A longer timeseries and further evaluation are necessary to determine whether the opinion survey can be used as a stock status indicator but this evaluation will be very difficult without other sources of

data, which as noted, may be compromised by reduced coverage.

Outlook for 1999

The 1995 and 1996 yearclasses are expected to be major contributors to the 1999 spawning stock. The analyses presented here indicate that these yearclasses are relatively abundant compared to other yearclasses. Even if average fish size is small in 1999, the presence of two relatively strong yearclasses would be expected to result in a spawning biomass in 1999 that is above average when compared to biomasses in the 1990's.

The TAC of 33,000 tons in 1998 was about 65% of the average inshore TAC (51,000 tons) during 1990-95 and about 79% of the average inshore TAC (42,000 tons) during 1982-89. Although there is a great deal of uncertainty in the indices, it would appear that the capelin stock has not exhibited any extreme changes in abundance during the 1990's. Given the above considerations, there is no biological basis to suggest alterations to this TAC.

The results from the mathematical model suggest that both the 1997 and 1998 yearclasses are weaker than the 1995 and 1996 yearclasses. The 1998 yearclass appears to be as weak as the 1991 yearclass, the weakest yearclass in the 1990's. If the relative strengths of these yearclasses do not change with additional data, then the capelin stock will probably decline in the future.

There have been many problems and uncertainties in assessing the capelin stocks in recent years in part perhaps to changing behaviour during unusual oceanographic conditions, as well as reduced directed scientific research. It is unlikely that future assessments will be improved at the current level of research activity.

Sizes of Females

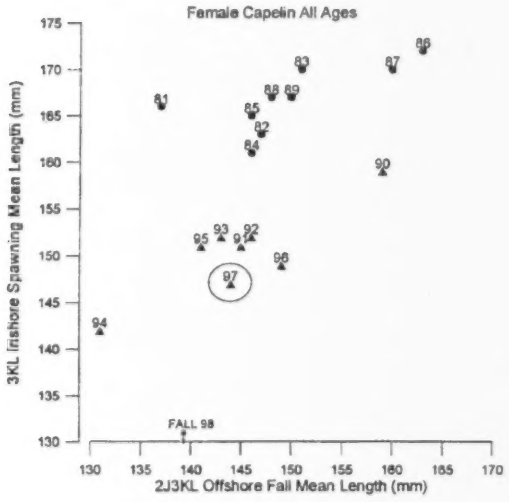
Because the size of females in 1997 had been incorrectly predicted from 1996 data, the evaluation of expected mean size of females in 1998 was modified. Two changes were made. First, data were grouped into two time periods, the 1980's and 1990's, because growth increments between fall and the following spawning season were different for these two time periods (specifically, growth in the 1980's was greater). Second, because it is not possible to predict whether growth will be more like the 1980's or the 1990's, the information was presented as two probability curves. These curves provided the probabilities of reaching mean lengths at spawning with a starting length measured in the fall under the two possible growth scenarios.

The mean length of maturing capelin in the fall of 1997 was 144 mm. The probability curves indicated that if growth was similar to the 1990's, there was about a 60% probability that the mean length of capelin in 1998 would be about 151 mm (average count of about 50). If however growth were more typical of the 1980's, there was a high probability that counts would be 50 or less.

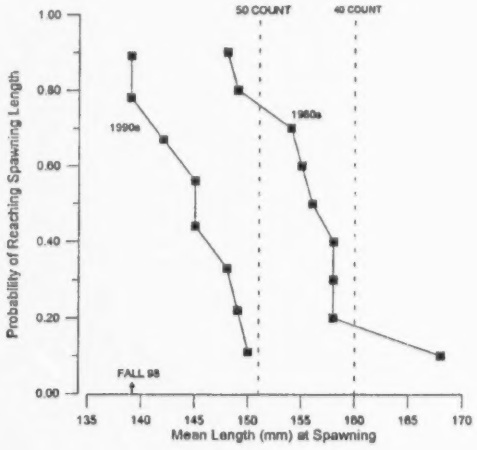
Sampling data from the 1998 fishery indicated that the mean length of females was 147 mm indicating that the increment between the fall of 1997 and spawning season of 1998 more closely resembled the increments from the 1990's. This average is estimated from pooled data from the entire

stock area and does not identify differences in mean lengths which might have been observed in the fishery.

The updated scatterplot of mean fall lengths and mean inshore lengths is shown below. The points are labelled according to the year the fall offshore data were collected. Therefore, the point representing length from the fall of 1997 and inshore in 1998 is labelled 97 and circled.



The probability curves have been recalculated using the mean length of 139 mm of maturing female capelin from bycatch in the 1998 fall groundfish survey in Div. 2J3KL. These curves can be used to provide guidance on approximate counts in the mature female population in 1999 (counts are approximate because the weight-length relationship varies during the maturation process), depending on whether growth is more typical of the 1980's or 1990's. If growth is similar to that observed in the 1990's, there is virtually no chance that the average count will be less than 50 in 1999. If growth is similar to that of the 1980's, there is a 75% chance that the average counts will be less than 50. As noted previously, the analysis is based on pooled data from the stock area and consequently, it is not possible to account for differences that may occur between geographical areas and between spawning runs.



For More Information

Research Document:

Anonymous. 1999. Capelin in SA2 + Div. 3KL. CSAS Res. Doc. 99/__.

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